# Electrical Machine

By Ankit Goyal Sir

GATE EE 2018 AIR 1

KREATRYX

www.kreatryx.com

# INDEX

## Chapter 1: Basic Introduction

1. Electrical material
    a. Conducting material
    b. Magnetic material
        i. Domain theory
        ii. Magnetic material type
    c. Insulating material
2. Basic laws of electromagnetism
    a. Biot – Savart's law
    b. Ampere's law
3. Electromagnetic induction
    a. Faraday's law
    b. Lenz's law
4. Type of induced E.M.F
    a. Statically induced E.M.F
    b. Dynamically induced E.M.F
5. Force produced by mag field
    a. Force on Moving charge
    b. Force on current carrying charge
6. Motional E.M.F

# INTRODUCTION

→ Electrical Material

i) Conducting Material
ii) Magnetic Material
iii) Insulating Material

## * Electrically Conducting Material

These materials carry current in elect. machine.

i) Highly Conducting Material
ii) Highly Resistive Material

Cu, Al, Au, Ag ⇒ HCM
Alloys ⇒ HRM

⇒ Heating element માટે highly Resistive material use થાય. જેમકે, ઈસ્ત્રી વગેરે.
⇒ શેના માટે Alloy (મિશ્ર ધાતુ) વપરાય છે.
⇒ Alloy of temperature co-efficient is low.
⇒ Resistance Alloy નું વધુ હોય.

## Property of Highly Conducting Material

⇒ Highest possible conductivity.
⇒ less temp co-efficient of Resistance.
⇒ Addiquete of Mechanical strength and absens of britleness.
⇒ Rollability and drawability should good.

$\sigma$ = Conductivity

$\sigma Au > \sigma Ag > \sigma Cu > \sigma Al$

{સૌથી વધુ condctive Au સોનું છે તે સોનું}

$\alpha Cu = 0.00393 / °C$

__/__/____

⟹ Good weldebility & sholderability to ensure low resistance of Joints

⟹ Addiquet Resistance to corrosion.

## <1.> Copper

⟹ Machine winding માં વપરાય.

⟹ Copper is resistant to oxidation and corrosion.

⟹ Hard drawn copper wires are used in electrical machine because there mechanical strength is high.

$$\alpha Cu = 0.00393 / °C$$

↑ Temp co-efficient of copper

## <2.> Aluminium

⟹ Since copper is getting depleted Alumi. is the next best choice for conducting material.

⟹ As it is ~~abedently~~ abundantly available

⟹ Aluminium can not be drawn into thin wire but it can be use for form thin plates

For same Resistance The cross section of Al is more than Cu

| Parameter | Cu | Al |
|---|---|---|
| Cost | 1 | 0.49 |
| Cross Section | 1 | 1.62 |
| Diameter | 1 | 1.27 |
| Volume | 1 | 2.04 |
| Weight | 1 | 0.49 |
| Strength | 1 | 0.64 |

we know, $\sigma_{Cu} > \sigma_{Al}$

σ = चालकता

$$R = \rho l / A = \frac{l}{\sigma A} \qquad (\rho = 1/\sigma)$$

$$R_{Cu} = R_{Al}$$

$$\frac{l}{(A\sigma)_{Cu}} = \frac{l}{(A\sigma)_{Al}}$$

$$(A)_{Al} = \frac{(A)_{Cu}\,(\sigma)_{Cu}}{(\sigma)_{Al}}$$

as the $\sigma_{Al} < \sigma_{Cu}$

we get $(A)_{Al} > A_{Cu}$

Interview

__/__/____

**Q** Why cross sectional Area is more than copper

⟹ કેમ કે, cu જેટલો loss રાખવા Area વધારવો પડે કારણકે Al ઓછુ conductive છે.

⟹ For aluminium wire the size of slot require is higher as compare to cu.

⟹ For induction motor above 100KW o/p Al can be used for cage rotor.

⟹ Al can be used to form foil type low voltage winding in transformer.

⟹ Al can be used to construct the tank of transformer to reduce stray losses.

⟹ Al is easily gets oxidised to form $Al_2O_3$ layer which prevent further oxidation.

## <3> Electrical Carbon

⟹ This material is made up of graphite or other form of carbon.

⟹ Conductivity of carbon is less than of cu & Al. but its surface is smoother so it is used to make brushes in an electrical machines.

Graphite has -ve temp co-efficient.

__/__/____

⟹ Carbon ~~brous~~ brushes are graphited ~~and~~ or heat treated to increase condctivity and increase smoothness.

⟹ Graphite has -ve temp co-efficient

So $T \uparrow \Rightarrow R \downarrow$

So $V_{BD} = IR \Rightarrow$ Brush drop is constant.

Cu ⟹ Winding ऱी

Al ⟹ Trans. Tank ऱी

Carbon ⟹ Brush ऱी

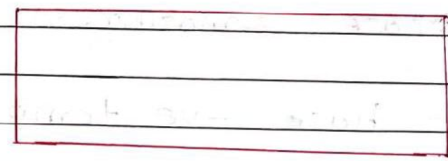
## Magnetic Materials

⟹ The material which allows flow of magnetic field through them are called as magnetic material.

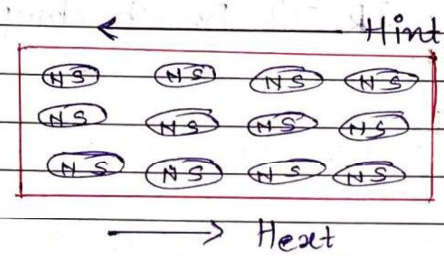
i> Diamagnetic Material
ii> Paramagnetic Material
iii> Ferromagnetic Material.

__/__/____

## (ii) Diamagnetic



no dipoles in absense of magnetic field.




⟹ In diamagnetic material there is no magnetism in absence of external field.

⟹ When magnetic field is applied dipoles are induced and they orient in direction opposite to external mag. field.

magnetization (M)
↓
ability of dipoles to align when mag. field is applied.

$\vec{M} = \chi_m \vec{H}$ ($\vec{H}$ = ext. mag field)
($\chi_m$ = mag. susceptibility)

↓
~~SIEPs~~
Pronounce as
SIEP

What is Susceptibility
What is Permeability

_/_/_

Susceptibility shows that for some value of magnetic field how are strong material get magnetize.

Susceptibility is a measure of material to get magnetize when external mag. field is applied.

in diamagnetic material

$\vec{M}$ & $\vec{H}$ are opposite to -

So $\chi_m < 0$

$\mu = \mu_0 \mu_r$

$\mu_0$ = Permeability of free space / vacuum
$= 4\pi \times 10^{-7}$ H/m
$\mu_r$ = relative permeability

$\mu_r = 1 + \chi_m < 1$ in diamagnetic.

So $\mu < \mu_0$

⟹ Permeability of material is related to ability of material to allow magnetic field lines to pass through it.

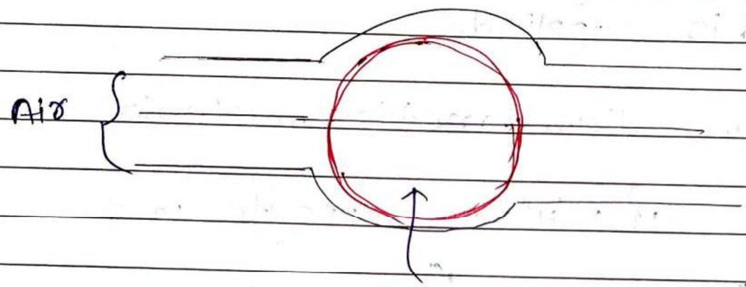
⟹ Magnetic flux density (B) represents the closeness of of magnetic field line to each other in unit surface area.

__/__/____

$\vec{B} = \mu \vec{H}$

$\mu < \mu_0$

$\therefore \vec{B}_{air} > \vec{B}_{diamagnetic}$




diamagnetic material.
માં feild line વચ્ચેથી ફેરવાઈ
બહાર જાય છે.

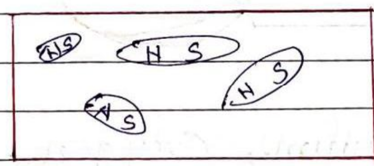
⟹ In a diamagnetic material the magnetic field line diverge away from each other.

ex: Cu, Silicon, Germanium, Gold
Diamond.

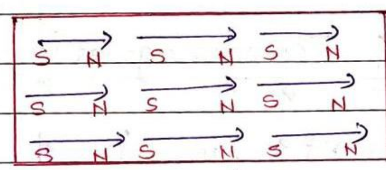
ડાયપોલ હોવાનું કારણ spin of unpaired electron.

## ★ <ii> Paramagnetic

⇒ In paramagnetic material the magnetic dipoles already exist due to spin of unpaired electron in an atom




→ H = 0




→ H

⇒ In paramagnetic materia magnetic diapoles are randomly oriented but when mag. field is applied such dipole align parallel to external mag. field.

$\vec{M} = \chi_m \vec{H}$

$\vec{m}$ Parallel to $\vec{H}$

So $\chi_m > 0$

$\mu_r = 1 + \chi_m > 1$

$\mu > \mu_0$

$\vec{B}_{air} < \vec{B}_{para}$